# Ecoregional Planning in a Coastal Marine Environment: Willamette Valley–Puget Trough–Georgia Basin

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Coastal ecoregions are under particular stress today as human populations concentrate in coastal zones. Estuarine and marine environments bear the cumulative impacts of land use and resource management decisions carried out in terrestrial and freshwater environments. At the same time, humans are exploiting marine fisheries with an efficiency that threatens to undermine trophic relationships and biodiversity, sometimes far from the sea itself. The decline of salmon in the Pacific Northwest, for example, has come from a combination of heavy fishing and damage to freshwater habitats, and this decline has in turn drastically reduced the transfer of marine nutrients upstream to terrestrial and freshwater locations. Yet, as a study in Washington State has shown, 138 species of terrestrial and aquatic wildlife rely directly or indirectly on ocean-derived nutrients from salmon carcasses.

Though varied, the methods and applicable information for marine ecoregional planning are improving rapidly. World Wildlife Fund recently completed plans for the Sula-Sulawesi Seas, the Meso-American Reef, and Nova Scotian Shelf. The Nature Conservancy has completed plans for the central Caribbean and northern Gulf of Mexico and is finishing plans for Cook Inlet in Alaska, Chesapeake Bay, and Puget Trough-Georgia Basin. The Conservancy and World Wildlife Fund have collaborated in a plan for the Bering Sea.

In response to marine conservation issues in the Pacific Northwest, The Nature Conservancy has developed methods for analyzing the nearshore marine environment in the ecoregion comprising Willamette Valley, the Puget Trough, and Georgia Basin and for integrating the results with terrestrial and freshwater analyses. The Puget Trough-Georgia Basin ecoregional plan offers an example of incorporating nearshore marine habitats and species into the Conservancy's roughly seven-step ecoregional planning process.

## Purpose and Participants

Ecoregional planning for Puget Trough and Georgia Basin aimed to identify a set of conservation areas (i.e., an ecoregional portfolio) that, if conserved, will protect a representative subset of the nearshore marine biodiversity of those waters. The process used a combination of data-driven models and expert opinion to develop a conservation portfolio.

The marine portfolio for the Puget Trough-Georgia Basin was developed at the same time as that region's freshwater and terrestrial portfolios, but the process involved a different group of scientists, and used distinct data sets and somewhat different modeling methods. A "marine team" was set up to identify habitat and species conservation targets, adapt data sets for analysis, set conservation goals, evaluate the relative viability of target occurrences, and assemble the portfolio. A wider circle of experts participated in the same steps through a series of workshops.

We used the planning process to expand existing partnerships and forge new relationships with state, provincial, and federal agencies; academia; and other environmental nonprofits engaged in marine science and conservation, including:

- Archipelago Marine Research LTD
- National Oceanic and Atmospheric Administration (National Marine Fisheries Service)
- Nature Conservancy Canada
- Department of Fisheries and Oceans (DFO)
- British Columbia Ministry of Sustainable Resources Management (MSRM) and its Conservation Data Centre (CDC)
- People for Puget Sound
- University of Washington
- United States Fish and Wildlife Service
- Washington Department of Natural Resources
- Washington Department of Fish & Wildlife (WDFW)

## Conservation Targets

The plan addressed 134 conservation targets, of which 40 were "coarse-filter" targets (nearshore marine ecosystems or habitats) and 94 were "fine-filter" targets (specific occurrences of marine organisms together with their habitats).

The coarse-filter targets comprised shoreline types derived from classifications developed in British Columbia and Washington. Fine-filter targets included rockfish and lingcod, forage fish (herring, sand lance, surf smelt), seabirds and shorebirds, marine mammals, and some invertebrates.

These targets do not represent **all** marine biodiversity in the ecoregion. The coarse-filter targets are nearshore habitat types; no comparable data were available to develop a portfolio of subtidal habitats. A long list of species qualified as fine-filter targets, including those listed as endangered or threatened, known to be declining, or of special interest (e.g., keystone species). Final targets were selected from among the best-known species, for which data were available throughout most of the ecoregion.

## Data and data gaps

We collected data for 103 targets (77 percent) in Washington and for 96 targets (72 percent) in British Columbia.

Data on shoreline and intertidal habitats came from the Washington Department of Natural Resources and the British Columbia Ministry of Sustainable Resource Management, which used the same techniques and classification in their inventories. These inventories identified linear reaches of shoreline by habitat type and annotated the records with information on vegetation (kelp, eelgrass, etc.) and shoreline modifications (e.g., percentage of shoreline with seawalls). For coarse-filter or habitat representation, we used shoreline segments defined by beach type and intertidal vegetation (14,942 shore units covering 8,070 kilometers or 5,014 miles).

Fine-filter data came from a variety of public agencies and marine expert workshops, specifically:

- Forage-fish spawning grounds (WDFW, MSRM)
- Rockfish and their adult habitats (WDFW) and rockfish closures (DFO)
- Seabird concentrations and nesting colonies (WDFW, MSRM, expert workshops)
- Marine mammal haul-outs and concentrations (WDFW, MSRM, expert workshops)
- Occurrences of rare or declining invertebrates (WDFW, CDC, expert workshops)

For these fine-filter targets, we used 750-hectare hexagons as planning units. We also included rockfish habitat point data in the hexagon analysis.

There were two substantial gaps in the data with respect to the chosen targets. All the rockfish or rockfish habitat came from depths less than 40 meters (as a result of the techniques used to collect the data). Invertebrate data were sparse, and therefore may have reflected neither the best nor the only sites where those species could be conserved.

Although we collected species data below 40 meters and used them in our analysis, we had habitat data only to 40 meters. We therefore did not include sites below this depth in the portfolio because we felt the species data alone could not support decisions about conservation priorities in deeper water. The resulting portfolio can generally be called a nearshore conservation plan, with a few exceptions in shoal areas away from shorelines. The total area encompassed within the 40-meter isobath was approximately 430,700 hectares (Figure 1).

## Conservation goals

The marine team set conservation goals on the basis of available information, which did not allow us to assess each target's viability. Goals identified how much (what percentage) of the target's present distribution should be contained within the portfolio. We used linear units for the shoreline types and area units for fine-filter data. We set an overarching goal to include 30 percent of the shoreline within the portfolio, with goals for individual shoreline types ranging from zero (artificial shorelines) to 40 percent. Higher goals were set for habitats with vegetation that support juvenile fish or shelter higher biodiversity across the entire intertidal zone.

Goals for fine-filter targets ranged from 30 to 60 percent, again on the basis of available data only. Goals for bottomfish and their habitats took relative abundance into account so that the model gave preference to habitats with more fish.

## Existing Areas and Efforts

In mapping existing marine protected areas and shoreside conservation areas, our marine team found that most had been designated for specific purposes and did not necessarily protect all the biodiversity within them (e.g., rockfish reserves prohibit bottom fishing but permit all other takings). This shortcoming, and limitations in the data, made it difficult to assess the effectiveness of existing conservation areas with respect to our chosen marine targets.

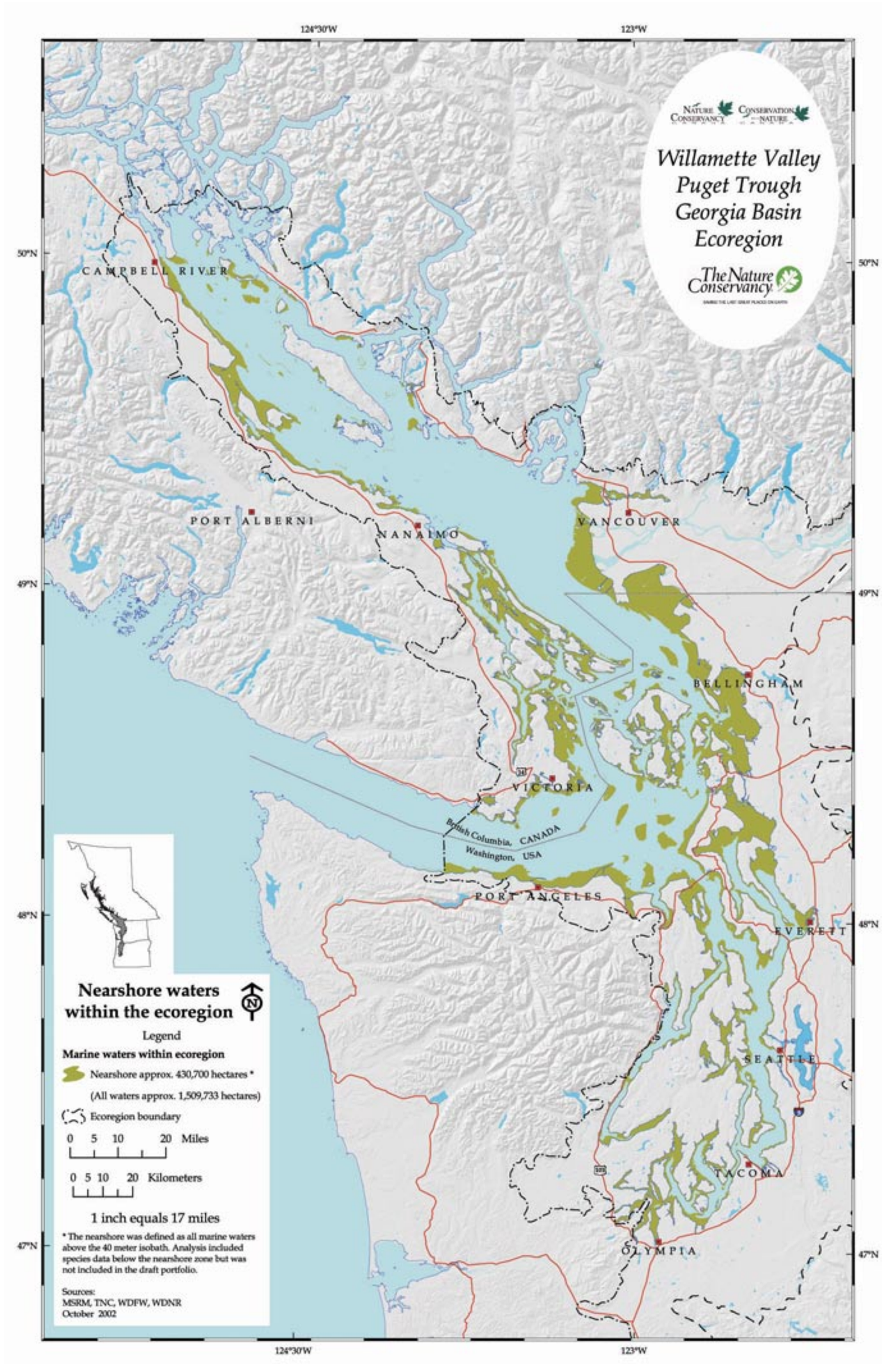


**Figure 1.** The nearshore conservation plan extends to the 40-meter depth, or approximately 430,700 hectares.

Where the reasons behind an existing conservation designation matched our targets—as for rockfish reserves—we ended up with good target representation in the portfolio. The portfolio selection process also confirmed the ecological value of the area included in the Orca Pass initiative—a grassroots effort to establish an international marine stewardship zone around the San Juan and Gulf Islands on the US-Canada border—and the Canadian Parks and Wilderness Society's work to identify priority marine reserves in the Southern Strait of Georgia.

## Viability Analysis

We had no way to assess viability for individual marine targets, so we tried to build elements of viability into the portfolio in several ways:

- We set a generous (30 percent) goal for all shoreline types combined and set goals for individual types to ensure that the portfolio represented all shoreline types in the ecoregion.

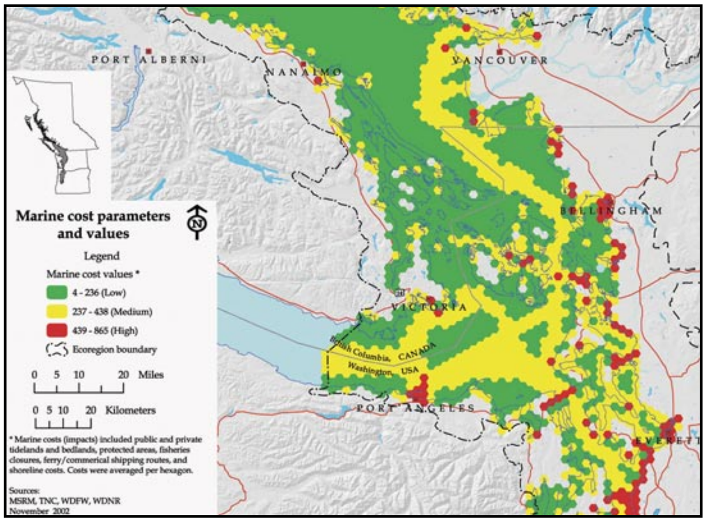


**Figure 2.** Nearshore cost parameters are classified here into three categories to form a cost range of four (lowest cost) to 865. This range fell within a range for terrestrial costs so that all values across ecosystems could be integrated when running the site selection algorithm.

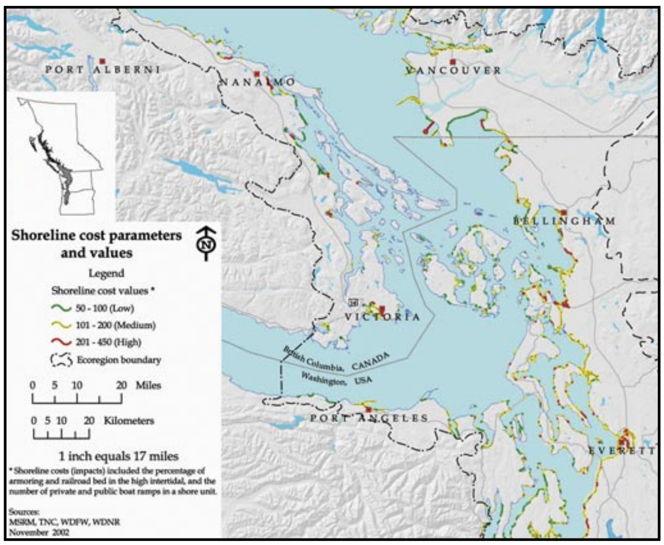


**Figure 3.** A shoreline cost was calculated from linear segments and added to both nearshore and terrestrial cost values.

- We constructed a "cost" algorithm, which operated on all terrestrial and marine planning units, as a means of driving the model toward the least disturbed examples of habitats.
- We gave preference to large, intact sites—the seascape sites identified by xperts—when modeled data confirmed at least portions of them as important.
- We weighted rockfish habitats by relative abundance of rockfish, so the most populated habitats were included in the portfolio.

To select priority conservation areas, we included in the analysis a "cost," or suitability, index, which tended to weed out sites with human uses or modifications that might restrict conservation and restoration options. The index consisted of nearshore cost parameters and shoreline modifiers. Nearshore cost parameters included public versus private ownership of tidelands, ferry and commercial shipping routes, fisheries closures, and marine reserves and other protected areas. Shoreline modifiers included the amount of armoring within a shoreline unit, presence of railroad beds in the high intertidal, and the number of public and private boat ramps. We averaged nearshore parameters within hexagon planning units, and we summed shoreline modifiers within the linear shoreline unit (Figures 2 and 3).

A preliminary analysis showed that approximately 433 kilometers (or 20 percent) of shoreline habitats in the draft portfolio lay within existing conservation areas. (The portfolio includes approximately 2,214 km of shoreline, or 29 percent of the ecoregion.) We did not include in the draft portfolio another 417 kilometers of shoreline that already had some level of protection. Limitations in the data make these findings very uncertain.

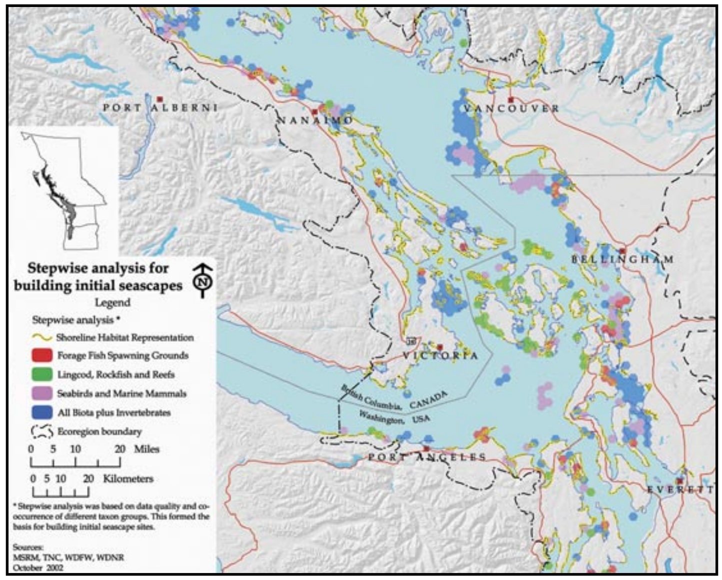


**Figure 4.** At tier 1, we ran a stepwise analysis on fine filter data to attempt to identify those areas with the most targeted biodiversity. These sites were compared with coarse filter representation in order to derive initial seascape sites.

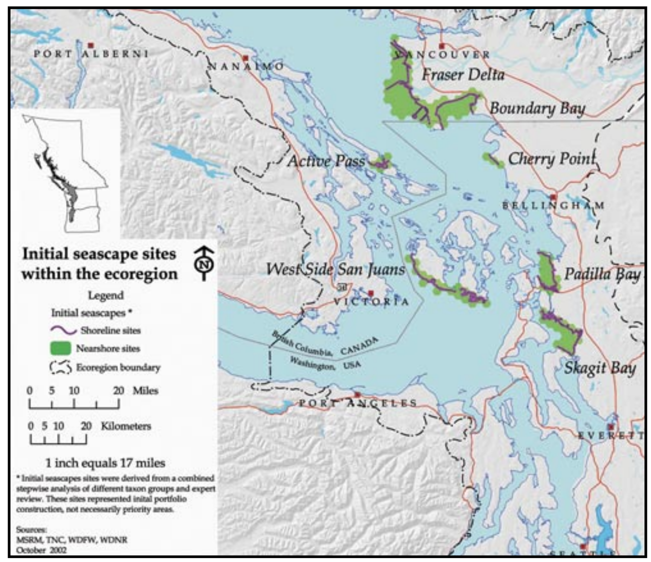


**Figure 5.** After expert review of analysis from tier 1, we came up with ten seascape sites represented in both shoreline and nearshore extents. These initial sites became the building blocks for subsequent analysis and review.

## Portfolio Assembly

During planning we moved back and forth between human expertise and results from spatial analysis, using each to test the other while refining the portfolio. Experts were especially helpful in identifying the large, relatively intact "seascapes" that best represented natural conditions at the land-sea interface. Once these sites were confirmed, they were locked in as a basis for subsequent analysis.

Running an optimal-reserve selection algorithm called SITES, we used two spatial planning units for the shoreline and nearshore environments (linear shore units and hexagons, respectively). We constructed a four-tier system that attempted to balance spatial analysis with expert input. At each tier we analyzed coarse- and fine-filter data, then called upon experts to choose irreplaceable sites for that stage; these then became the locked-in sites for subsequent model runs (Figure 4 and 5).

## Initial conclusions

This portfolio (Figure 6) made important contributions to ecoregional planning for coastal environments and established a regional benchmark for marine ecosystem health because we were able to:

- Rely on comprehensive shoreline habitat data throughout the ecoregion, which provided a basis for detailed regional analysis.
- Find fishery-independent data for some marine fish species, including spatially explicit information on critical habitats (e.g., rocky reefs, forage fish spawning beaches).

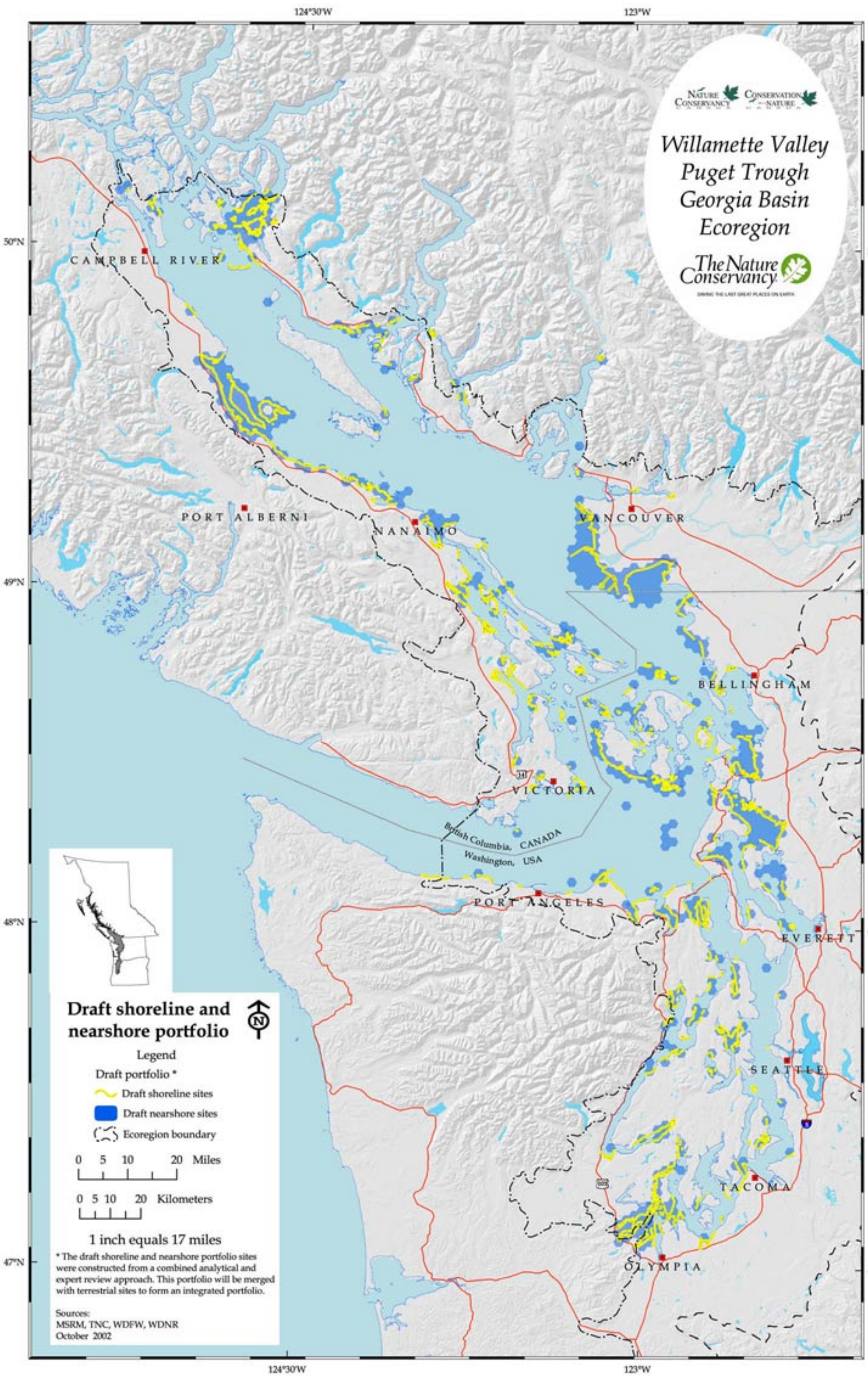


**Figure 6.** The final draft nearshore marine conservation portfolio. Results were 3,053 shoreline units (2,112 km) captured, or 28% of the total shoreline length. This final draft was then integrated with terrestrial and freshwater portfolios in order to delineate sites across ecosystems.

- Develop new methods for aggregating raw survey data, running an optimal-reserve algorithm on linear shoreline habitats, and using a consistent index of landscape alteration across marine and terrestrial data sets.
- Integrate a wide range of expert opinion and successive analytical runs throughout the planning process.

The Puget Trough–Georgia Basin plan was the first iteration in a dynamic process. In the future, new data will help us update and improve the plan. Two general constraints limited this initial portfolio:

- In comparison with the state of terrestrial knowledge, information on the distribution and status of marine habitats and organisms is limited. No applicable data existed on the distribution of habitats below 40 meters, for example, and we had data for only selected habitats below low tide.
- The analysis focused on selecting sites where the targeted biodiversity occurred. The SITES algorithm and existing data sets did not link sites or optimize the portfolio in terms of ecological processes or connectivity.

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